

# Roundabouts

Florida's Implementation Strategy

# Overview

- Roundabouts - Proven Safety Countermeasure
- Florida Standards
- Hot Topics
- Organizational Support

# Proven Safety Countermeasure



[Return to FHWA Office of Safety Web Site](#)

## Office of Safety Proven Safety Countermeasures



*These nine countermeasures address crashes that occur in the focus areas of intersections, pedestrians, and roadway departure.*



Improving safety is a top priority for the U.S. Department of Transportation, and FHWA remains committed to reducing highway fatalities and serious injuries on our Nation's highways. We are highly confident that certain processes, infrastructure design techniques, and highway features are effective and their use should be encouraged.



2012 "Guidance Memorandum on Promoting the Implementation of Proven Safety Countermeasures" ([HTML](#), [PDF](#) 78 KB)

In January 2012, FHWA issued a "[Guidance Memorandum on Promoting the Implementation of Proven Safety Countermeasures](#)". This guidance takes into consideration the latest safety research to advance a group of countermeasures that have shown great effectiveness in improving safety. Safety practitioners are encouraged to consider this set of countermeasures that are research-proven, but not widely applied on a national basis.

Click on one of the nine countermeasures below for more information and a downloadable fact sheet. Each fact sheet provides more detailed descriptions, related research studies, and evaluations of each of these countermeasures. Further information on each countermeasure can also be found at the Crash Modification Factors Clearinghouse (<http://www.cmfclearinghouse.org/>).



[Roundabouts](#)



[Corridor Access Management](#)



[Backplates with Retroreflective Borders](#)



[Longitudinal Rumble Strips and Stripes on Two-Lane Roads](#)



[Enhanced Delineation and Friction for Horizontal Curves](#)



[Safety Edge<sup>SM</sup>](#)



[Medians and Pedestrian Crossing Islands in Urban and Suburban Areas](#)



[Pedestrian Hybrid Beacon](#)



[Road Diet](#)

## Proven Safety Countermeasures

### Roundabouts



U.S. Department of Transportation  
Federal Highway Administration



FHWA-SA-12-005

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You may need the [Adobe Reader](#) to view the PDFs on this page.

By converting from a **two-way stop** to a roundabout, a location can experience an 82% reduction in the number of fatal/injury crashes and a 44% reduction in all crashes.



The modern roundabout is a type of circular intersection defined primarily by three basic operational principles:

- Geometry that results in a high level of safety, creating substantial safety advantages.
- Entering traffic yields to circulating traffic in the circulatory roadway, leading to excellent operational performance.
- Channelization at the entrance and deflection around a center island are designed to be effective in reducing conflict.

### Background

There are an estimated 300,000 signalized intersections in the United States. About one-third of all intersection fatalities occur at these locations, resulting in roughly 2,300 people killed each year. Furthermore, about 700 people are killed annually in red-light running collisions. Although traffic signals can work well for alternately assigning the right-of-way to different user movements across an intersection, roundabouts have demonstrated substantial safety and operational benefits compared to most other intersection forms and controls, with especially significant reductions in fatal and injury crashes. The Highway Safety Manual (HSM) indicates that:

- By converting from a two-way stop control mechanism to a roundabout, a location can experience an 82 percent reduction in severe (injury/fatal) crashes and a 44 percent reduction in overall crashes.
- By converting from a signalized intersection to a roundabout, a location can experience a 78 percent reduction in severe (injury/fatal) crashes and a 48 percent reduction in overall crashes.

The benefits have been shown to occur in urban and rural areas under a wide range of traffic conditions, and ongoing research has expanded our collective knowledge on safety performance for specific scenarios. Although the safety performance of a two-way stop control is comparable to roundabouts (per the HSM), roundabouts provide far greater operational advantages. Roundabouts can be an effective tool for managing congestion in a high-traffic area that moves traffic from a high-speed to a low-speed environment. However, proper site selection, channelization, and design features are essential for making roundabouts accessible to all users.

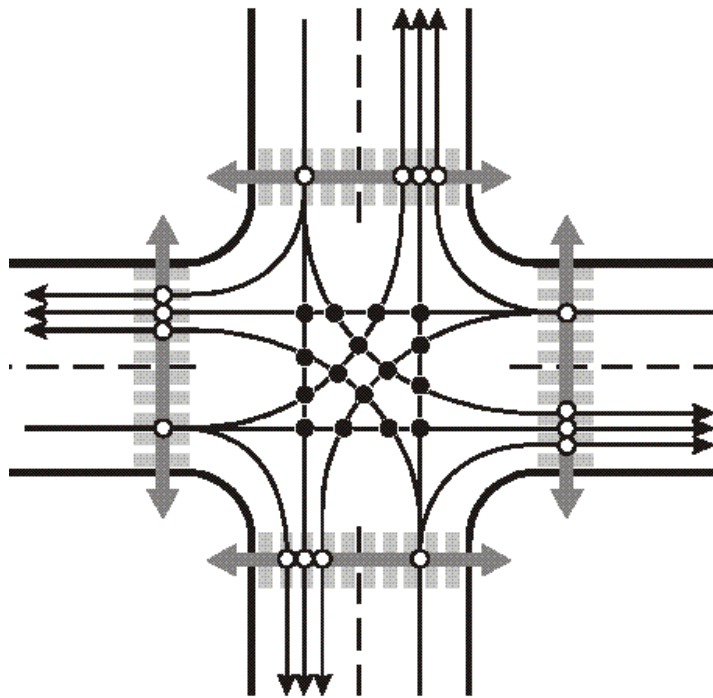
### Guidance

Roundabouts should be considered as an alternative for intersections on federal highways. Roundabouts should also be considered when rehabilitating existing intersections. Roundabouts have also proven to be effective at freeway interchange ramp terminals.

By converting from a **signalized intersection** to a roundabout, a location can experience an 78% reduction in the number of fatal/injury crashes and a 48% reduction in all crashes.

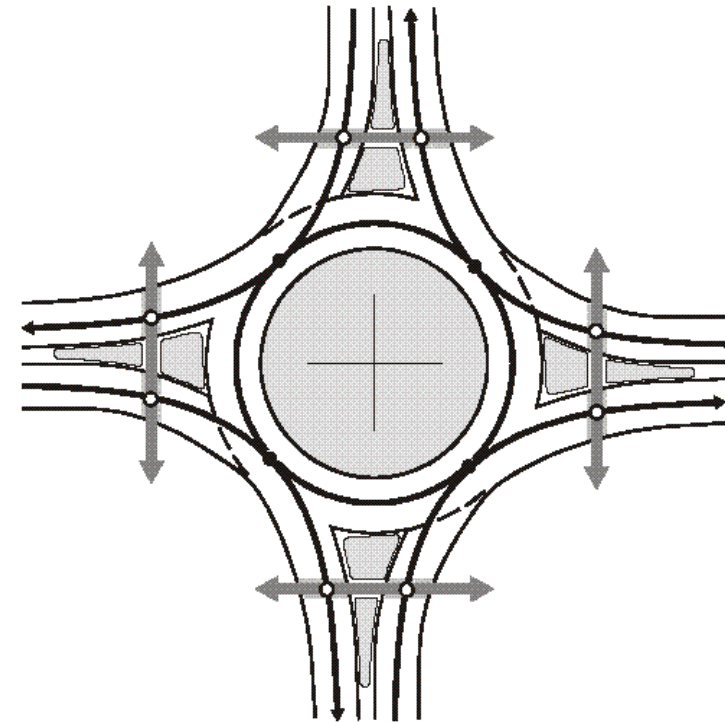
or reconstruction.  
operational improvements.

# Proven Safety Countermeasure



○ Vehicle/Pedestrian Conflicts

**32 Vehicle Conflicts**  
**16 Pedestrian Conflicts**

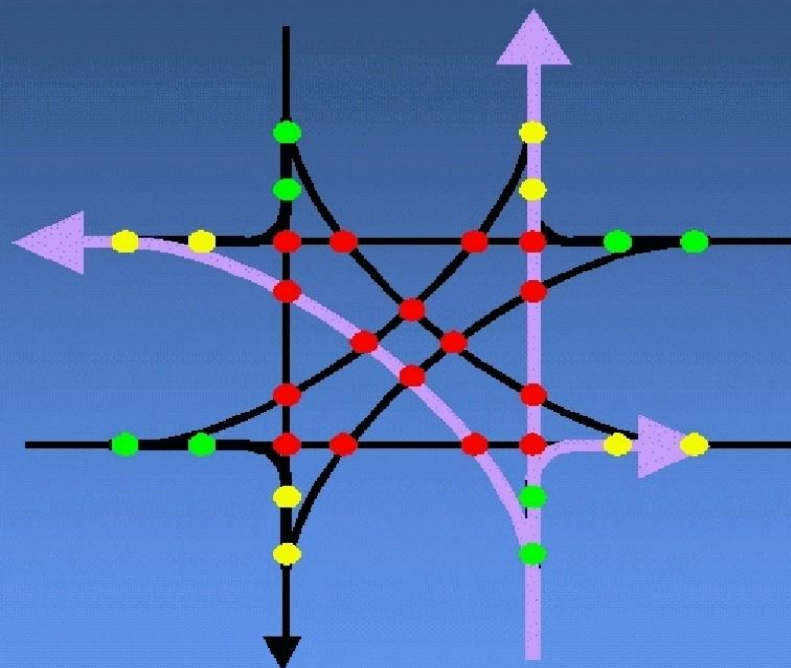


○ Vehicle/Pedestrian Conflicts

**8 Vehicle Conflicts**  
**8 Pedestrian Conflicts**

# Conflicts

## Vehicle conflict points: Conventional intersection

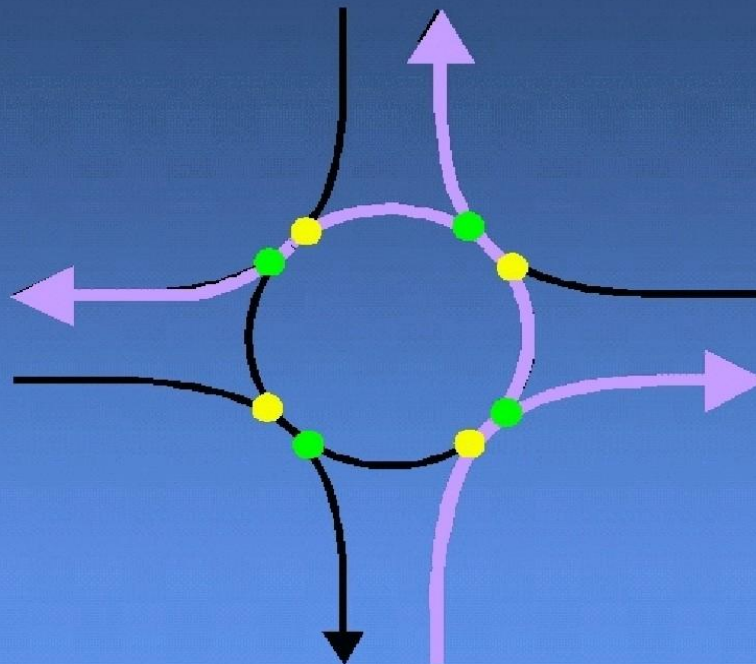


### Conflict Types

● Diverge:	8
● Merge:	8
● Crossing:	16
Total:	32

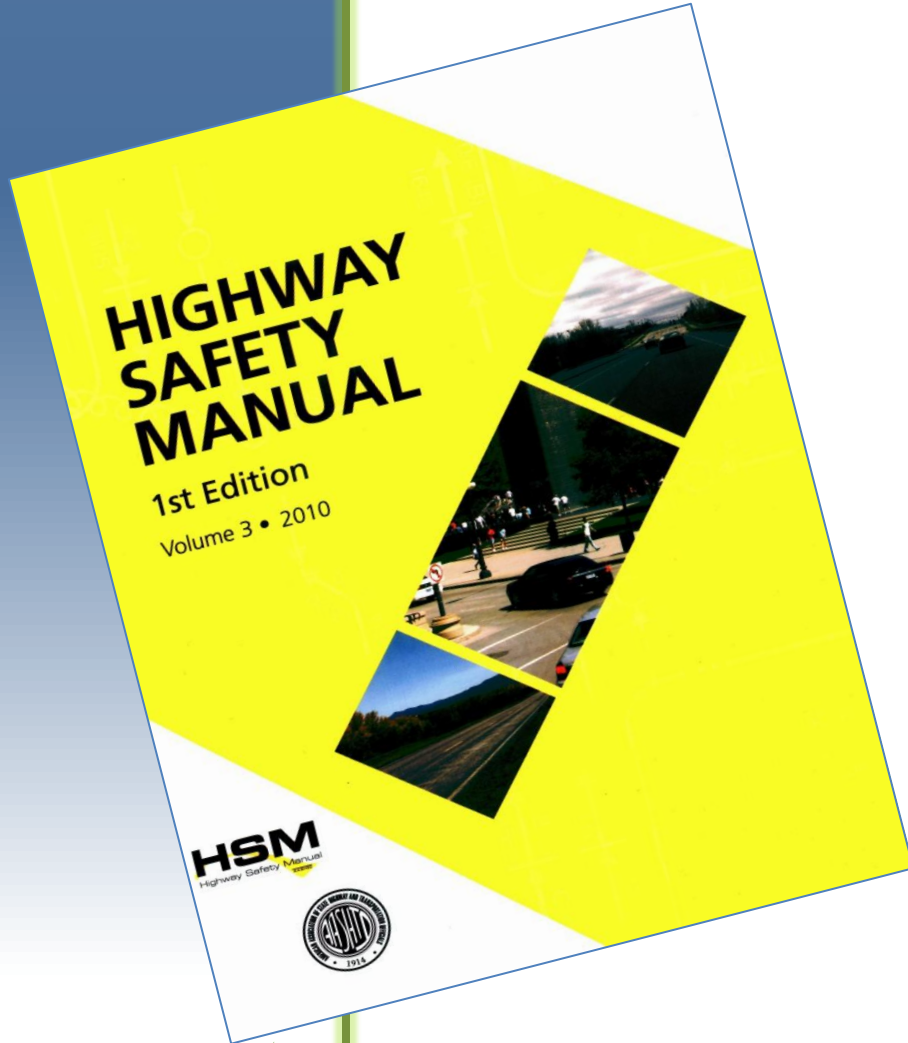
# Conflict Reduction

## Vehicle conflict points: Roundabout



Conflict Types	
● Diverge:	4
● Merge:	4
● Crossing:	0
<hr/>	
Total:	8

# Highway Safety Manual



## •Florida Implementation

- District Training
- Planning
- PD&E
- Design
- Construction
- Operations & Maintenance

# Crash Modification Factors

**Table 14-4.** Potential Crash Effects of Converting a Stop-Controlled Intersections into a Modern Roundabout (29)

Treatment	Setting (Intersection Type)	Traffic Volume	Crash Type (Severity)	CMF	Std. Error
Convert intersection with minor-road stop control to modern roundabout	All settings (One or two lanes)	Unspecified	All types (All severities)	0.56	0.05
			All types (Injury)	0.18	0.04
	Rural (One lane)		All types (All severities)	0.29	0.04
			All types (Injury)	0.13	0.04
	Urban (One or two lanes)		All types (All severities)	0.71	0.1
			All types (Injury)	0.19	0.1
	Urban (One lane)		All types (All severities)	0.61	0.1
			All types (Injury)	0.22	0.1
	Urban (Two lanes)		All types (All severities)	0.88	0.2
	Suburban (One or two lanes)		All types (All severities)	0.68	0.08
			All types (Injury)	0.29	0.1
	Suburban (One lane)		All types (All severities)	0.22	0.07
			All types (Injury)	0.22	0.1
	Suburban (Two lanes)		All types (All severities)	0.81	0.1
			All types (Injury)	0.32	0.1
Convert all-way, stop-controlled intersection to roundabout	All settings (One or two lanes)		All types (All severities)	1.03*	0.2

# Crash Modification Factors

14-10

HIGHWAY SAFETY MANUAL

**Table 14-3.** Potential Crash Effects of **Converting a Signalized Intersection into a Modern Roundabout** (29)

Treatment	Setting (Intersection Type)	Traffic Volume	Crash Type (Severity)	CMF	Std. Error
Convert signalized intersection to modern roundabout	Urban (One or two lanes)	Unspecified	All types (All severities)	0.99*	0.1
			All types (Injury)	0.40	0.1
	Suburban (Two lanes)		All types (All severities)	0.33	0.05
	All settings (One or two lanes)		All types (All severities)	0.52	0.06
			All types (Injury)	0.22	0.07

Base Condition: Signalized intersection.

NOTE: **Bold** text is used for the most reliable CMFs. These CMFs have a standard error of 0.1 or less.

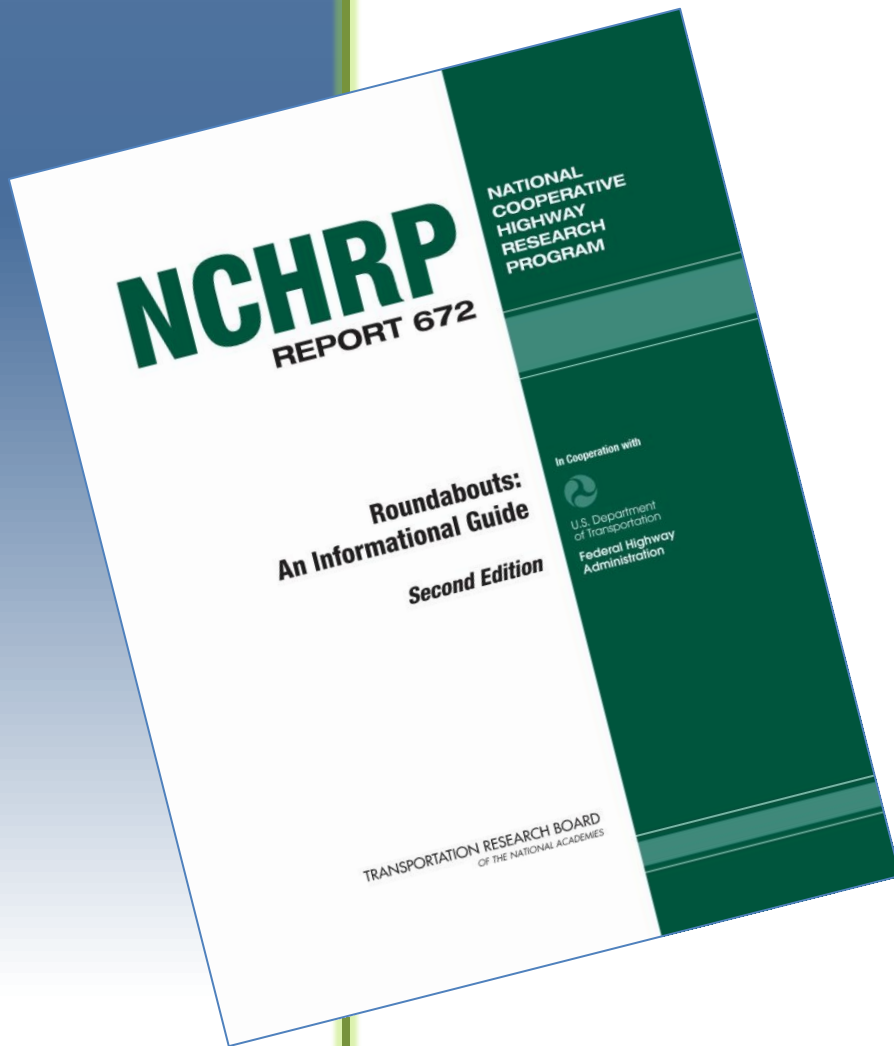
\*Observed variability suggests that this treatment could result in an increase, decrease, or no change in crashes. See Part D—Introduction and Applications Guidance.

The study from which this information was obtained does not contain information related to the posted or observed speeds at or on approach to the intersections that were converted to a modern roundabout.

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# Florida Standards



- **FHWA Adopted**
  - Use it Now!
- **Roundabout Task Team**
  - Fully Vetted
- **Florida Adoption**
  - New Policy
  - FDOT Publications
  - “Florida-centric” Issues

# “Florida-centric” Issues

## •Guidance for Application

- Screening
- Geometry
- Operational Analyses
- FDOT Publications
- Landscaping
- Lighting
- Driver Education

# Screening

- New Construction
- Reconstruction
- Operational Improvements
- Safety Improvements
- New Interchanges
- Interchange Modifications
- Complete Streets
- Safety Benefits in PD&E/VE Analyses

# Geometry

- Site Constraints
- Single-Lane
- Multi-Lane
- Design Vehicle
- Functional Analysis
- Sight Distance
- Future Widening
- R/W Availability/Costs
- Planning/PD&E Costs

# Operational Analyses

- NCHRP 672 Chapter 4
- Isolated Intersection (HCS)
- System Simulations

# FDOT Publications

- Plans Preparation Manual
- Design Standards
- Florida Greenbook
- Florida Intersection Design Guide
- PD&E Manual
- Manual on Uniform Traffic Studies
- Florida Roundabout Guide

# Landscaping

- Aesthetics
- Community Structures
- Walls
- Mounding
- Trees & Turf
- Shrubbery
- FDOT Maintenance Policy

# Lighting

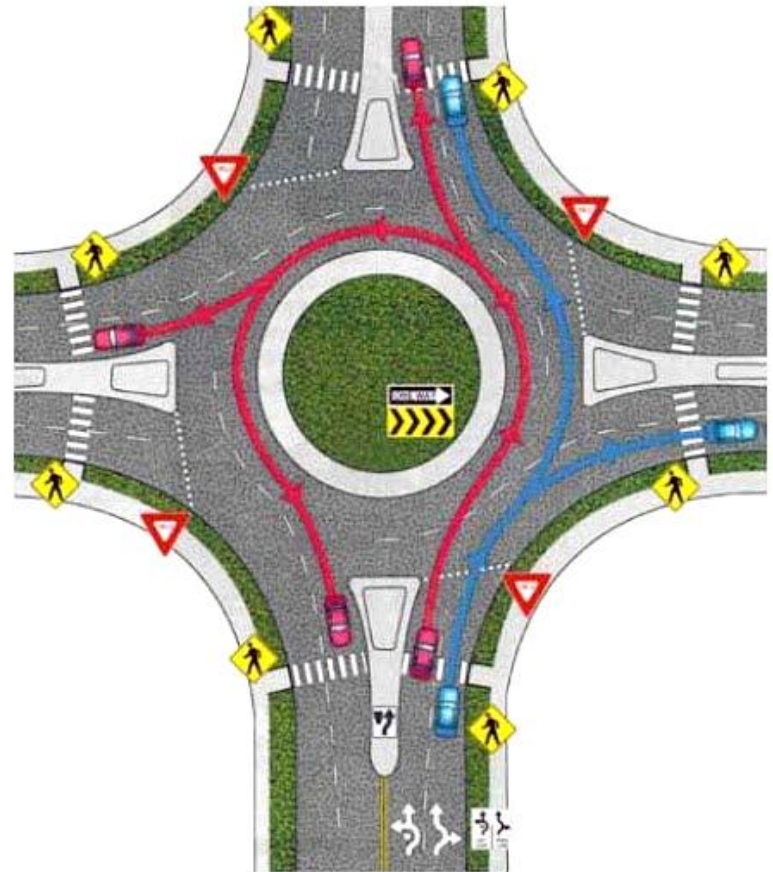
- Required at ALL Roundabouts
- Pole Location
- Level of Illumination

# Driver Education

- DHSMV
- High School

## 5.15 - Roundabouts

Roundabouts are circular intersections with no traffic signal which improve traffic flow and reduce traffic crashes. Roundabouts slow vehicle speed, give drivers more time to judge and react to other vehicles or pedestrians. Drivers entering the roundabout must yield to traffic already in the circle and are directed in one-way, counterclockwise direction. For multi-lane roundabouts, stay in the left lane to turn left and the right lane to turn right, and all lanes to go through, unless otherwise directed by signs or pavement markings. Stay in your lane within the roundabout and use your right turn signal to indicate your intention to exit. Prior to entering or exiting the roundabout, drivers must yield to pedestrians in the crosswalks. Bicyclists may take the lane in the roundabout, or use the sidewalk.



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An aerial photograph of a large, multi-lane roundabout with a central green island. Several cars are visible on the roads. A large red starburst graphic with a yellow outline is positioned at the top center, containing the text 'HOT TOPICS'.

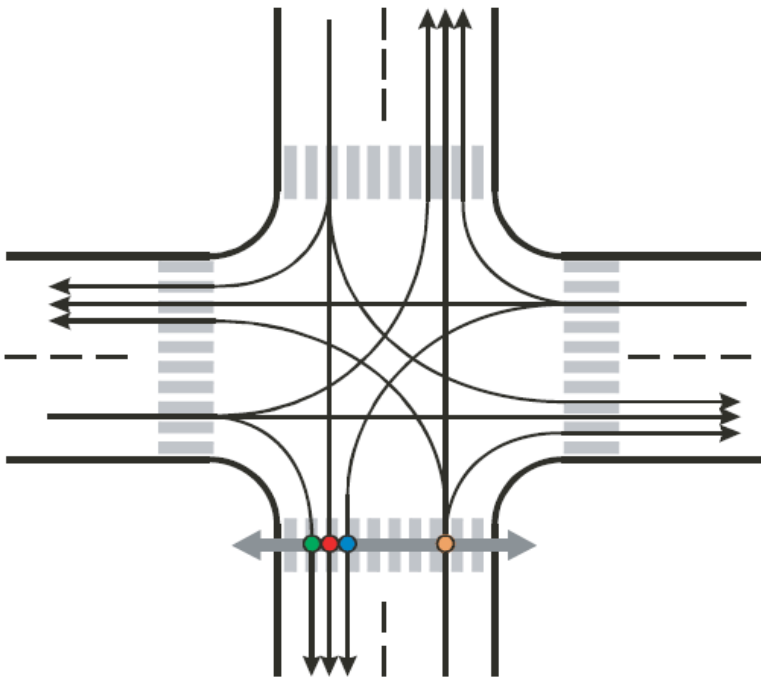
# HOT TOPICS

- Pedestrians
- Trucks
- Pavement Markings

# Pedestrian Issues

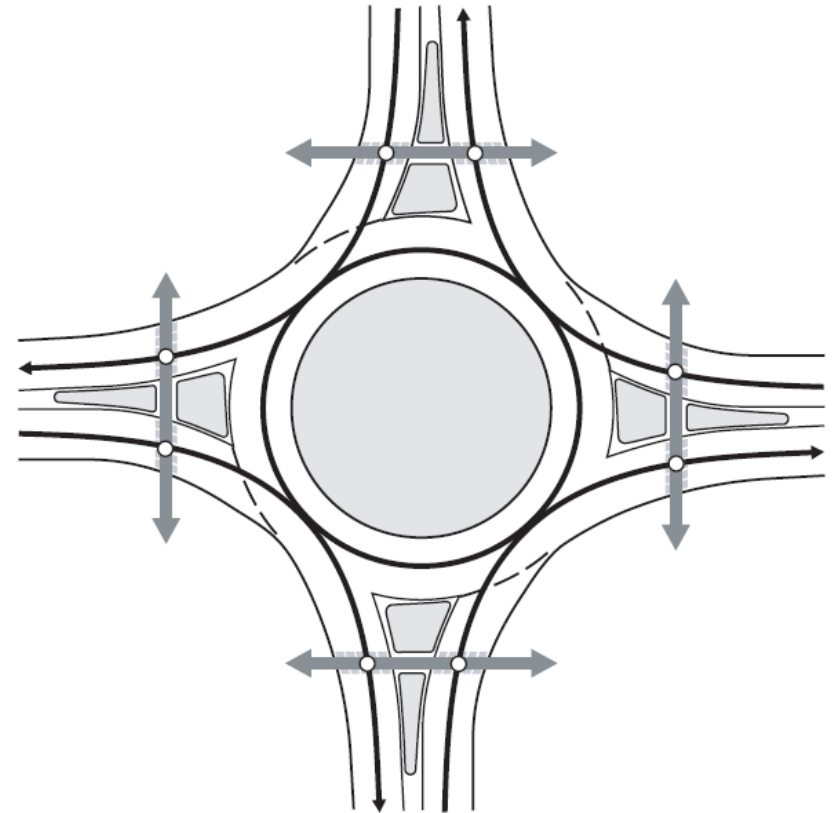
1. Basic safety considerations of crossing roundabouts
2. Historical studies of pedestrian safety
3. Design and traffic control devices
4. Effects of pedestrian performance modification on drivers

# Why Roundabouts are Safer?



- Right turn on green conflict
- Red light running conflict
- Left turn on green conflict
- Red light running or right turn on red conflict

**16 Pedestrian Conflicts**



○ Vehicle/Pedestrian Conflicts

**8 Pedestrian Conflicts**

# Why are Roundabouts Safer?

- The crossing distance is shorter, and pedestrians only have to watch for traffic in one direction at a time
- Traffic speeds are lower, giving pedestrians and drivers more time to judge gaps and react to each other
- Drivers are more likely to be looking in the direction of pedestrians
- At signalized intersections, approaching drivers are looking up at the signals, and turning drivers are watching for oncoming traffic and not where they are going (i.e. looking left while turning right)

# Pedestrian Safety Studies

- A 1993 study in the Netherlands at 181 intersections found that pedestrian crashes dropped 73% and pedestrian casualties dropped 89%
- Evaluations in Sweden showed a 78% reduction in injuries at single-lane roundabouts, and little change at multi-lane roundabouts
- The Melbourne metro area in Australia experiences 1 pedestrian crash per year for every 9 signalized intersections, and 1 pedestrian crash per year for every 364 roundabouts

# Cyclist Safety Studies

## (side bar)

- A study in Sweden at 72 locations concluded that at single-lane roundabouts cyclists were involved in 20% fewer injury crashes
- At multi-lane roundabouts they were twice as likely to be involved in injury crashes (although these were classified as “light” injury crashes)
- A study in western France at 1,238 signalized intersections and 179 roundabouts found that two-wheeled vehicles were involved in crashes more often at roundabouts (+16%), but were involved in injury crashes more often at signalized intersections (+77%)
- Studies in the Netherlands have shown that roundabouts decrease cyclist injuries by 44% to 73%

# Design and Traffic Control Devices

## Rectangular Rapid Flashing Beacon (RRFB)

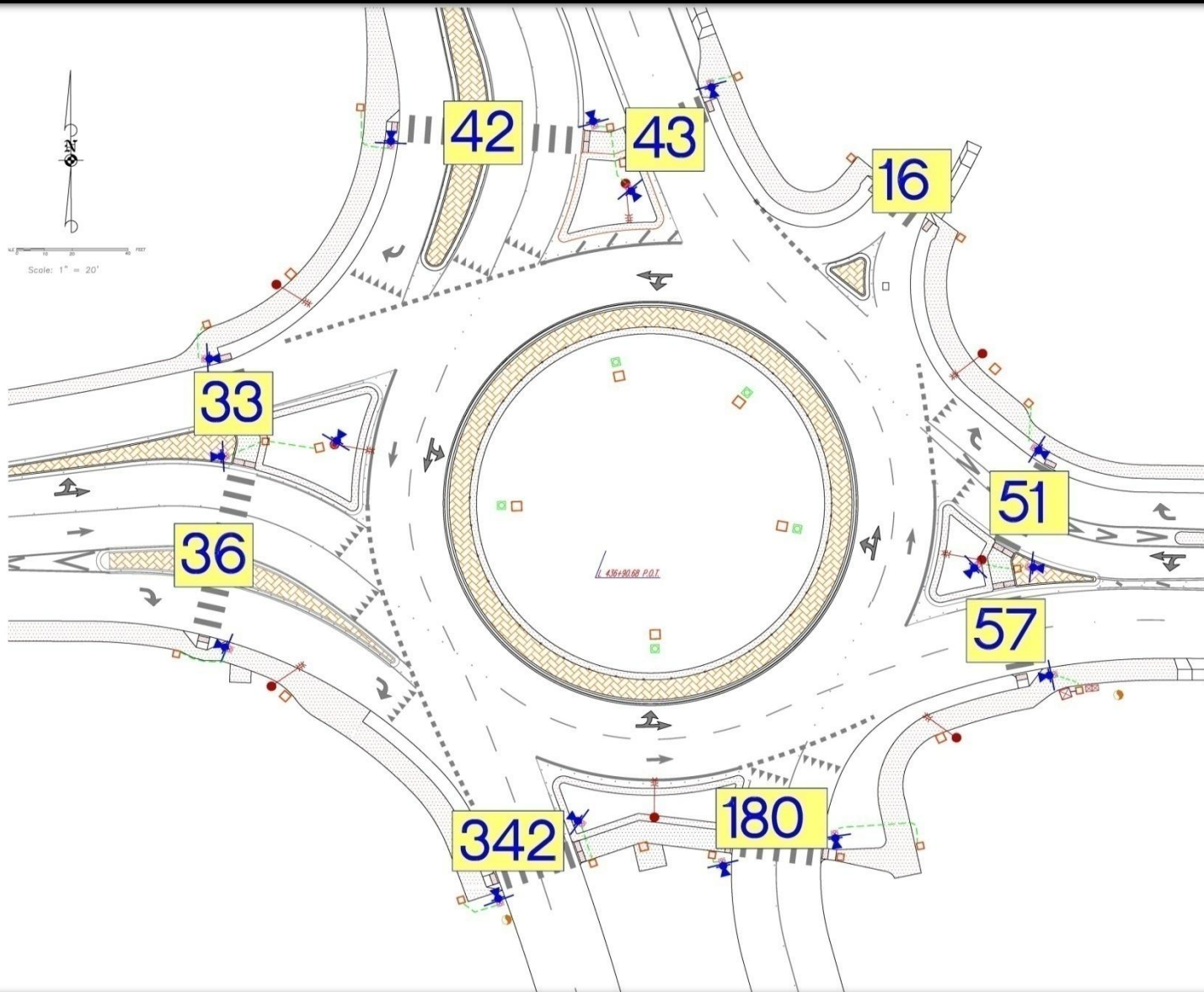


Case Study:  
**Three R's – Roundabouts,  
Rectangular  
Rapid Flashing  
Beacons, and Research**  
Kristi Krueger, Richard Perry  
and Brian Barnett , City of  
Springfield, Oregon

# Rectangular Rapid Flashing Beacon



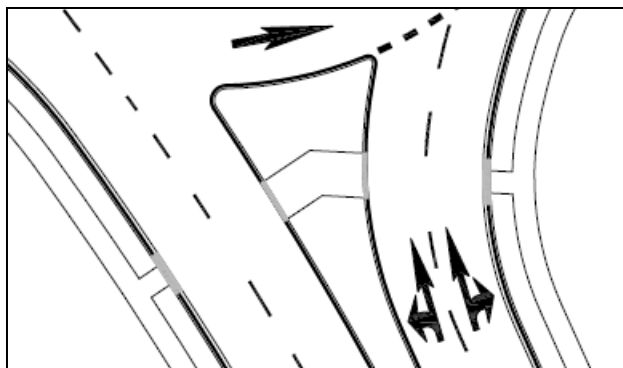
# Average Weekday RRFB Activations



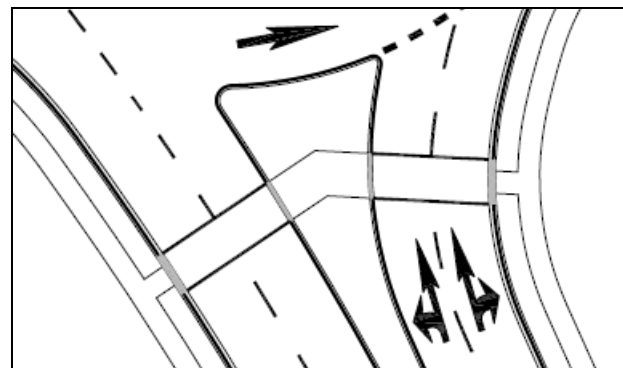
# Pedestrian Signals At Roundabouts (Gatineau, Quebec c. 2006)



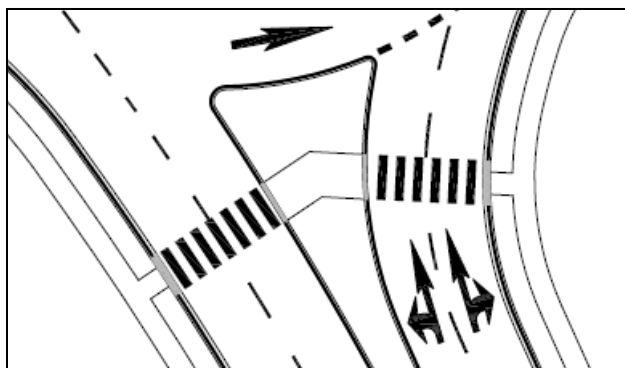
# Examples of Crosswalk Markings



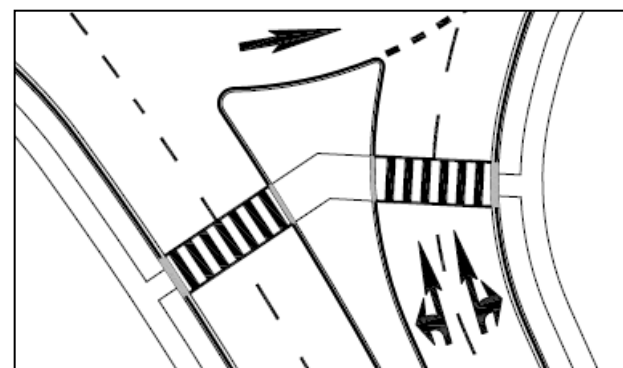
Unmarked



Marked



Meets MUTCD



FDOT Standard

**Special Emphasis used for Uncontrolled Intersections**

# Angled Pedestrian Crossing – Ladder Style (Caltrans Preferred & FDOT Standard)



# Pedestrian Design Principles

- Crosswalks are installed at roundabouts where there is a reasonable chance of pedestrian activity (required within urban area boundaries)
- Crosswalks should be located one vehicle length (or a multiple) behind the yield line to separate the driver tasks of looking for pedestrians and looking for oncoming traffic
- Curb cuts and ramps should be provided on the outer curbs and splitter islands
- Splitter islands should be wide enough to provide a refuge area between crossing traffic entering and exiting the roundabout (6' min.)

# Example of a preferred design treatment for roundabout crosswalks



# Visually-Impaired Pedestrians

- Visually-impaired pedestrians can find roundabouts difficult to navigate because of the continuous movement of motor vehicle traffic
- Standard treatments help them locate the crosswalk
- Extra treatments can be used to help them decide when it is safe to cross such as accessible pedestrian signals

# High-Contrast Tactile Surfaces (Required at all Ramps)



# Audible Pedestrian Signals



# Driver and pedestrian behavior studies

- An "assertive" pedestrian was 5.6-times as likely to have a driver yield for them (B. Schroeder, 2006)
- Pedestrian crossings for 10 sites showed 4 conflicts out of 769 pedestrian crossings - conflict rate of 2.3 conflicts per 1,000 opportunities. (NCHRP Report 572)
- Study of multilane roundabout crosswalk treatments determined that the more "assertive" study participants successfully "triggered" more yield events (NCHRP 3-78A).

# Driver and pedestrian behavior studies

- Drivers' willingness to yield to pedestrians is affected by whether they are attempting to cross at the entry or exit to the roundabout, and under some conditions by the presence of a long cane.
- Getting drivers to yield may require assertive pedestrian behavior.
- A vehicular speed of 18 mph at an entry lane offers a 9 in 10 chance that a driver will yield.
- A vehicular speed of 10 mph at an exit lane offers a 6 in 10 chance that a driver will yield.

Source: Journal of Visual Impairment and Blindness 05-05

# 'Assertive' or 'Positive' Pedestrian Behavior



## Positive Behavior:

- Approach crosswalk briskly and deliberately
- Scan for a gap and look directly at drivers
- Step up to the curb or even stand with one foot in crosswalk
- Point across the crosswalk to show intent
- Cross as soon as the driver slows or stops to yield

# “Look Smart” Loveland, CO

- P **P**oint and look
- E **E**ye contact
- D **D**ecide



# Conclusion/Assertion

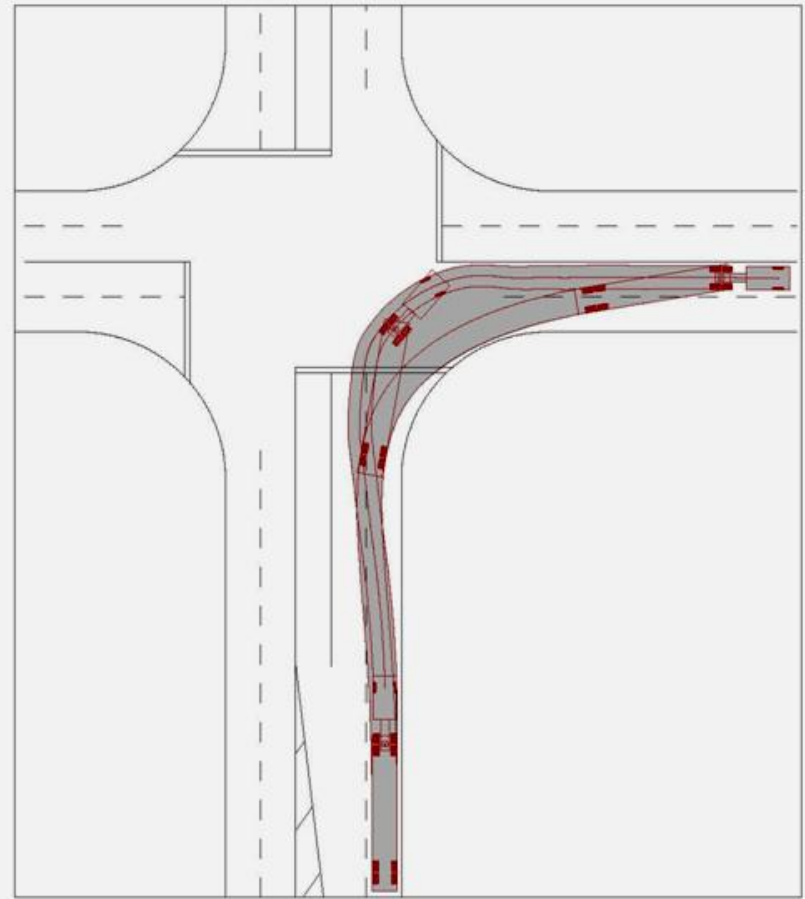
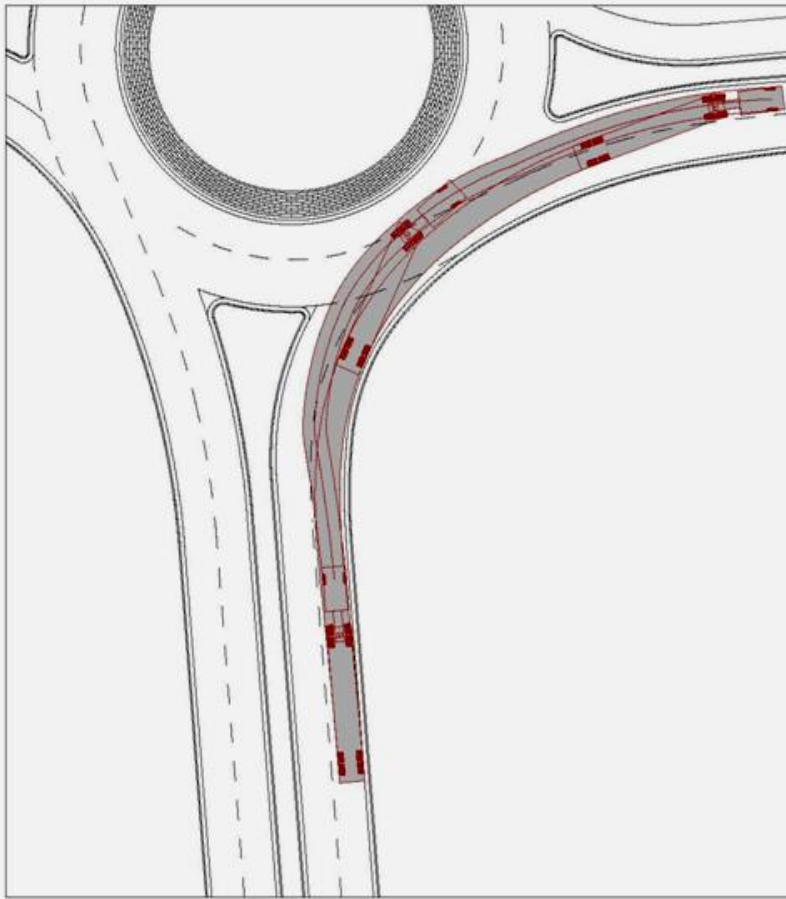
- Physical treatments alone will result in a one-sided approach to accessibility.
- No amount of engineering can compensate for a lack of education and enforcement.
- Training pedestrians to step up to the curb and point across the roundabout, and continue to point in the crosswalk is a simple and effective action to trigger a yield response from drivers.

# Trucks and Roundabouts

## Design Space Challenges and Impacts

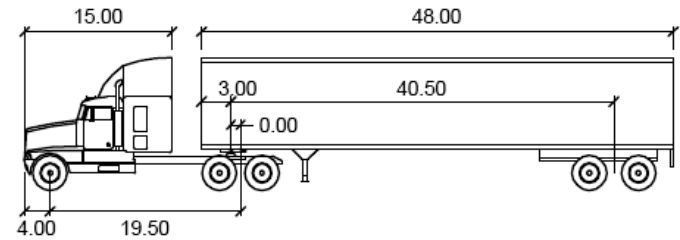
# Truck Right Turns:

Are roundabouts being held to a higher standard?



# N. American Truck Sizes

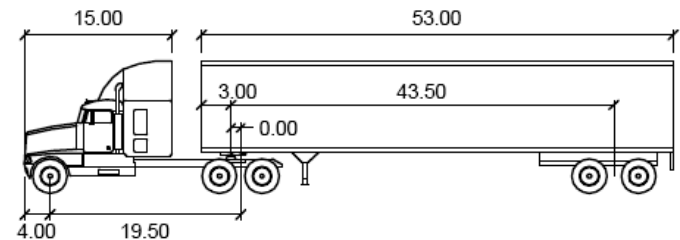
- Although these are not as common by percentage as smaller trucks and all other vehicles...
- ...designs are held to this standard which impacts size (cost), speed, pedestrian crossing etc. (safety)



WB-62

feet

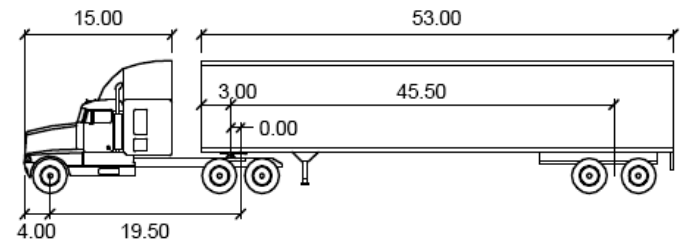
Tractor Width	: 8.00	Lock to Lock Time	: 6.00
Trailer Width	: 8.50	Steering Angle	: 28.40
Tractor Track	: 8.00	Articulating Angle	: 70.00
Trailer Track	: 8.50		



WB-65

feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.00
Trailer Width	: 8.50	Steering Angle	: 28.40
Tractor Track	: 8.00	Articulating Angle	: 70.00
Trailer Track	: 8.50		



WB-67

feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.00
Trailer Width	: 8.50	Steering Angle	: 28.40
Tractor Track	: 8.00	Articulating Angle	: 75.00
Trailer Track	: 8.50		

# Design Vehicle Requires Truck Apron



# N. American Trucks = Larger Layouts than in the UK



# Current Research

- WiSDOT/ MnDOT pooled fund study of standard design vehicles and roundabouts
- Goal to establish design guidelines for standard trucks
- Categorization:
  - Case 1 - No lane discipline entering or circulating
  - Case 2 – Lane discipline entering but not circulating
  - Case 3 – Lane discipline throughout
- Early results show case 2 most prevalent. More stakeholder consultation is needed

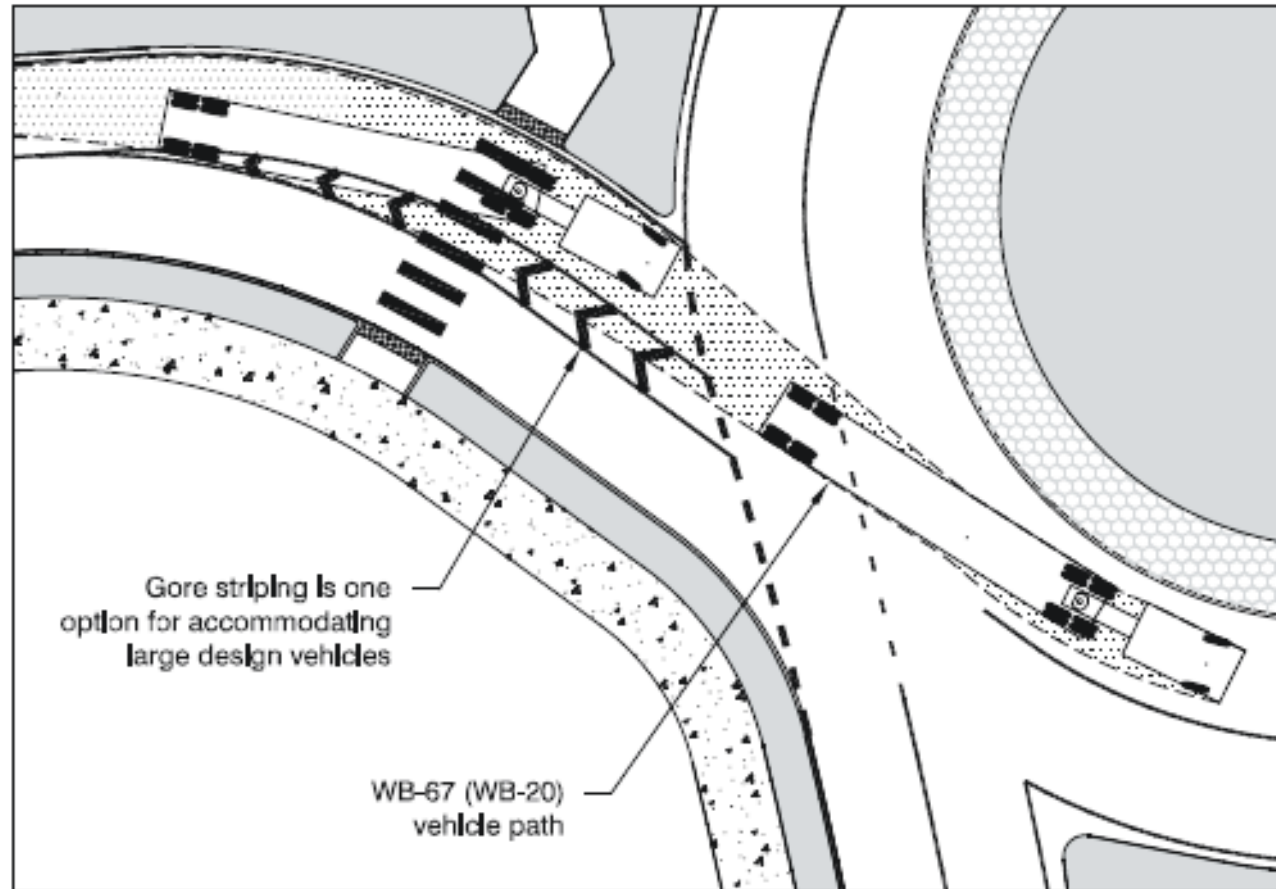
# Case 1 - Roundabout Design Without Circulating Stripes



# Case 2 Roundabout Design



# Case 3 - A trend toward wider faster entries, longer crossings, larger circles



Source: New York State Department of Transportation (11)

# Case 3 Roundabout Design



# Case 1 vs. Case 2 vs. Case 3

- As roundabouts are better able to accommodate trucks, they become larger and faster
- This can lead to less speed control at the entry, with lower yield potential and a higher probability of entry-circulating crashes
- This can result in higher construction costs and greater property impacts
- Accommodating trucks lengthens pedestrian crossing distances

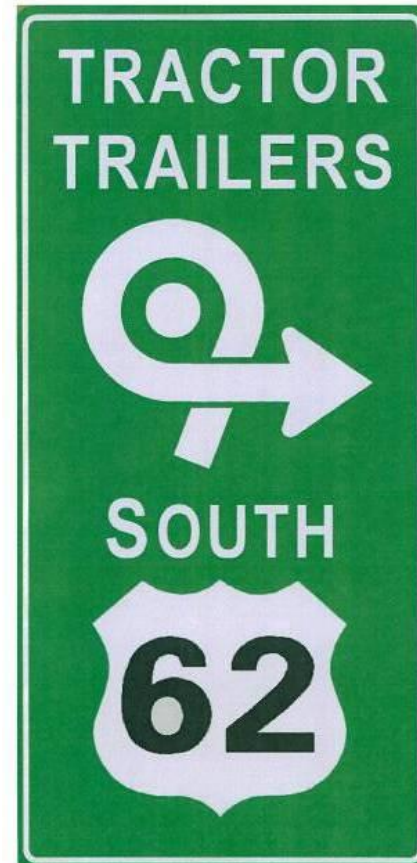


## Truck Encroachment sign

- Optional where the circulatory road has lane lines and the design does not allow for trucks and cars to circulate side-by-side

Supplemental tab (optional)

# Treatments for the most compact of circles



# Early Conclusions (the first 20 year)

- Roundabouts are showing great benefits in crash reduction and congestion relief.
- They are a just-in-time solution for complete streets in urban areas.
- Compact designs are ideal but have trade-offs (bigger is not always better).
- Designs for the largest vehicles are feasible and the trend is toward promoting lane discipline.

# Circulatory Markings & Advance Guide Signing at Roundabouts

# Strategic Design Using Markings

- Signing and pavement markings are essential to the design of complex roundabouts
- Geometric design does most of the work
- Signing and pavement markings help with lane choice and legal definitions
- **Markings cannot compensate for poor geometry**

# Consequences of Poor Geometry

- Violation of regulatory traffic circulation
- Incorrect lane choice – exit crashes
- Sudden lane changes
- Weaving in the circle
- Improper left turns
- Navigational and way-finding errors

# NCHRP 672 Chapter 7 - Signing and Marking



**Proper signing and marking help drivers anticipate the roundabout.**

# Pavement Markings – Two Schools of Thought

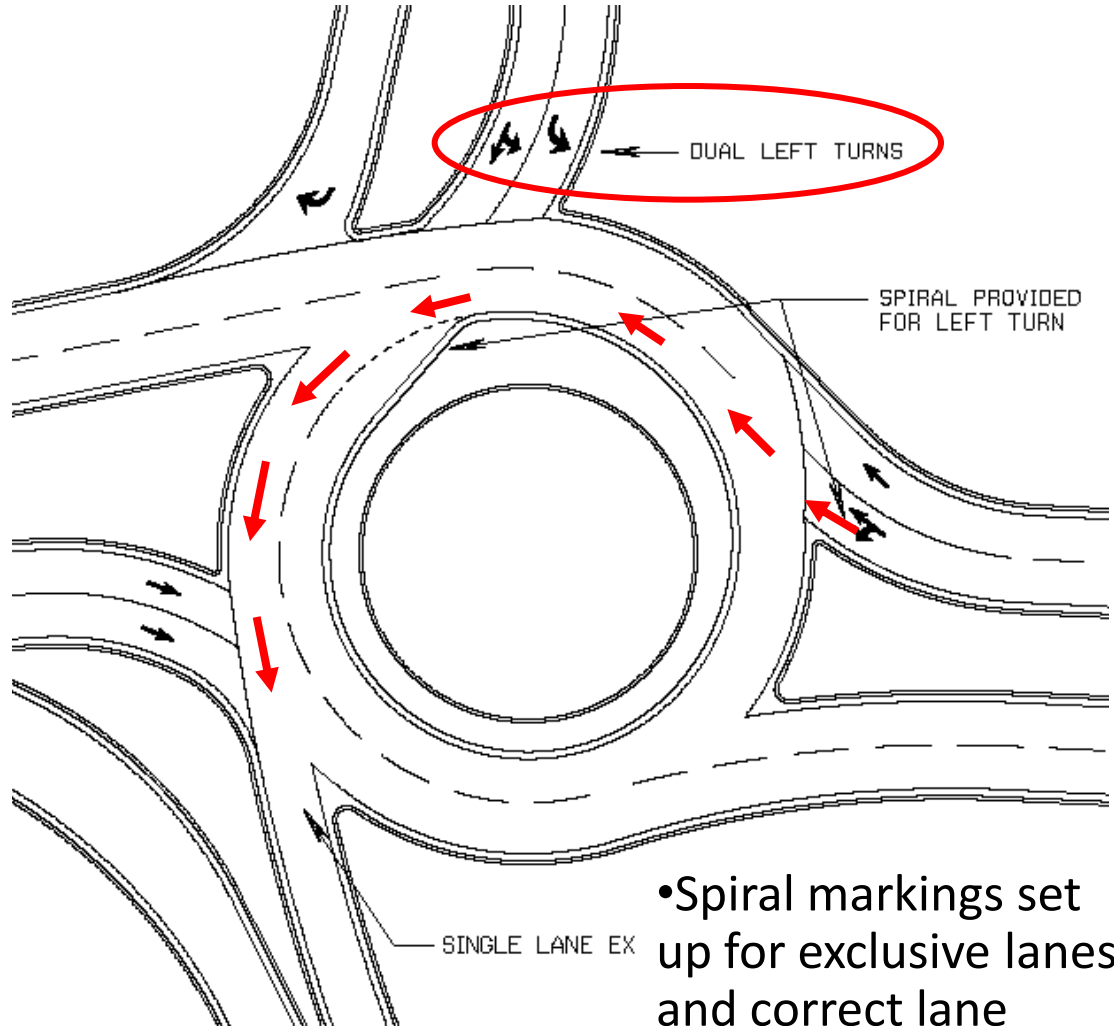
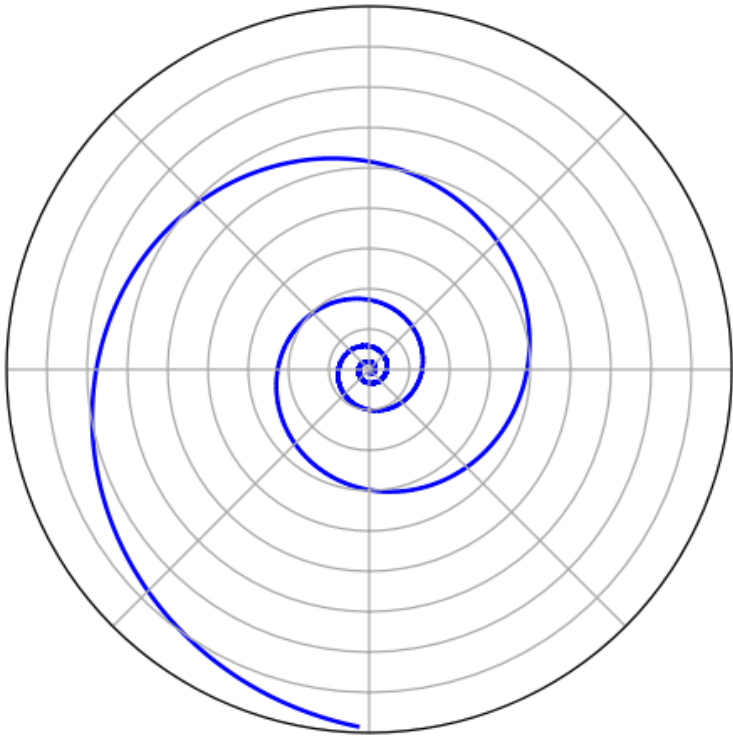
1. Provide only necessary pavement markings in the circulatory roadway
2. Provide full lane designation using pavement markings in the circulatory roadway

# Summary Advice 2003-2008

- Advised FHWA to *INITIALLY* exclude stripes
- Don't use solid lines
- Most 2 lane roundabouts do not need stripes
- Stripe special cases – double left turn
- Lots of misinformation out there - many ways to get it wrong
- No stripes better than bad stripes
- Can be surprisingly complex and subtle
- Every situation is different - case specific
  - Avoid rigid rules
  - Apply principles

# Traffic affects markings/affects geometry

## Log spiral



- Spiral markings set up for exclusive lanes and correct lane choice for exiting traffic

# Benefits of Circulatory Striping and Lane Arrows

- Improves capacity
  - Typically up to 20%
  - Can be more in exceptional cases
- Can improves safety
- Lane discipline reduces speed
- Obeying lane discipline is easiest for motorist
- Teaches how to correctly drive roundabouts
- Driver comfort and acceptance

# Generalized Conditions Before and After Circulatory Stripes

## Before (1990-2003)

- Incorrect lefts
- Inadequate guide signs on approach
- Trucks have all the space they need – no aprons on 2 lane roundabouts
- More compact circles
- Narrower pavement
- Exit tapers were more effective (merge starts at entry)
- Path overlap but mostly geometry related

## After (2003 – Current)

- Incorrect lefts
- Inadequate guide signs on approach
- New exit conflict with failing to yield
- Trucks/cars space – aprons on all multilane
- Wider lanes, faster entries
- Capacities are improved but not needed yet
- Path overlap avoidance

# Where circulatory stripes were not needed



# Where partial circulatory stripes are helpful



# Why should circulatory stripes be researched?

- We had limited experience with circulatory stripes when they were introduced
- We need to explore what impacts and benefits they have produced
- We need to refine their use and applicability
- Approach guide signs and markings are closely related
- Explore the role of geometry, e.g. exit tangency

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# Organizational Support

- Implementation with HSM
- District Champions
- CO Support
  - Design Support
  - Criteria & Standards
  - Design Review
- Training



# Roundabouts

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